IEC 62941

Edition 1.0 2019-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Terrestrial photovoltaic (PV) modules – Quality system for PV module manufacturing

Modules photovoltaïques (PV) pour applications terrestres – Système de qualité pour la fabrication des modules photovoltaïques

IEC 62941:2019-12(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 27.160

ISBN 978-2-8322-7625-9

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – QUALITY SYSTEM FOR PV MODULE MANUFACTURING

FOREWORD

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The text of this International Standard is based on the following documents:

FDIS	Report on voting
82/1635/FDIS	82/1641/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – QUALITY SYSTEM FOR PV MODULE MANUFACTURING

1 Scope

This document is applicable to organizations manufacturing photovoltaic (PV) modules certified to IEC 61215 series and IEC 62108 for design qualification and type approval and IEC 61730 for safety qualification and type approval. The design qualification and type approval of PV modules depend on appropriate methods for product and process design, as well as appropriate control of materials and processes used to manufacture the product. This document lays out best practices for product design, manufacturing processes, and selection and control of materials used in the manufacture of PV modules that have met the requirements of IEC 61215 series, IEC 61730, or IEC 62108. These standards also form the basis for factory audit criteria of such sites by various certifying and auditory bodies.

The object of this document is to provide a framework for the improved confidence in the ongoing consistency of performance and reliability of certified PV modules. The requirements of this document are defined with the assumption that the quality management system of the organization has already fulfilled the requirements of ISO 9001 or equivalent quality management system. This document is not intended to replace or remove any requirements of ISO9001 or equivalent quality management system. By maintaining a manufacturing system in accordance with this document, PV modules are expected to maintain their performance as determined from the test sequences in IEC 61215 series, IEC 62108, or IEC 61730.

This document is applicable to all PV modules independent of design and technology, i.e. flat panel, concentrator photovoltaic (CPV). Quality controls for CPV and nonconventional flat-plate manufacturing will differ somewhat from those of more conventional designs; this document has not considered these differences.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60812: *Failure modes and effects analysis (FMEA and FMECA)*

IEC 60891, *Photovoltaic devices – Procedure for temperature and irradiance corrections to measured I-V characteristics*

IEC 60904-1, *Photovoltaic devices – Part 1: Measurement of photovoltaic current-voltage characteristics*

IEC 60904-2, *Photovoltaic devices – Part 2: Requirements for photovoltaic reference devices*

IEC 60904-3, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 60904-4, *Photovoltaic devices – Part 4: Reference solar devices – Procedures for establishing calibration traceability*

IEC 60904-7, *Photovoltaic devices – Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices*

IEC 60904-9, *Photovoltaic devices – Part 9: Solar simulator performance requirements*

IEC 61215 (all parts), *Terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61730-1, *Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction*

IEC 61730-2, *Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

IEC 61853-1, *Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating*

IEC 62108, *Concentrator photovoltaic (CPV) modules and assemblies – Design qualification and type approval*

IEC 62759-1, *Photovoltaic (PV) modules – Transportation testing – Part 1: Transportation and shipping of module package units*

IEC TS 62915, *Photovoltaic (PV) modules – Type approval, design and safety qualification – Retesting*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement*

ISO 9001:2015, *Quality management systems – Requirements*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC TS 61836 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
containment
action taken to protect the customer from the effect of a harmful situation

Note 1 to entry: Containment may include correcting an existing situation or adding additional screening or retesting.

3.2
control plan
documented description of the systems and processes, and controls required for maintaining the product and process quality as well as reaction to non-conformance

3.3
customer
end user, investor, installer who purchases modules from the organization for their own use

3.4
design lifetime
design target period during which PV modules are expected to safely satisfy the specified performance under the specified conditions

Note 1 to entry: Specified conditions include application of use, installation environment configurations and operation conditions of the PV module in use. The design target period is set considering changes in performance of PV modules due to aging degradation of parts and materials used in the stated environment.

3.5
Design Failure Mode and Effects Analysis
DFMEA
application of the Failure Mode and Effects Analysis (FMEA) method specifically to design activities related to the product/service

3.6
Define, Measure, Analyse, Improve, Control
DMAIC
data-driven quality strategy for improving processes and an integral part of a Six Sigma quality initiative

3.7
Electrostatic discharge
ESD
transfer of electric charge between bodies of different electric potential in proximity or through direct contact

Note 1 to entry: Electrostatic discharge (ESD) events are known to damage semiconductor devices such as diodes.

3.8
Failure, Modes and Effects Analysis
FMEA
document that defines the design, process, or solution with requirements and includes potential modes, causes and severity of effects of failure, along with an evaluation of the likelihood of their occurrence and ease of detection

Note 1 to entry: FMEA provides a mechanism to prioritize the risks and take appropriate mitigation steps.

3.9
key materials
those materials that affect safety, reliability, product performance, or lifetime of the PV module

Note 1 to entry: Key materials may include indirect materials. Those materials which are used during the manufacturing process of PV modules, but are not found in the end product. In most chemical processes, catalyzers are indirect materials.

3.10
organization
entity that supplies modules to the customer and that has responsibility for design, production, and after-sales service for the modules or entity that owns the trademark of the PV modules

Note 1 to entry: The organization may subcontract some of its responsibilities for design, production, and the after-sales service.

3.11
out of control action plan
OCAP
supporting document to an SPC (Statistical Process Control) chart

Note 1 to entry: An OCAP is typically presented as a flowchart that guides manufacturing floor employees' reactions to out-of-control situations.

Note 2 to entry: An OCAP consists of activators (which define out-of-control conditions); checkpoints (which are likely causes for the conditions); and terminators (which contain the action that should resolve the conditions).

Note 3 to entry: OCAPs should be dynamic and updated continually as and when new knowledge and information become available. A frequently occurring OCAP activator is an indication of a systemic issue in the process.

3.12
Plan, Do, Check, Act
PDCA
four-step process for quality improvement

Note 1 to entry: In the first step (Plan), a way to affect improvement is developed. In the second step (Do), the plan is carried out, preferably on a small scale. In the third step (Check), a study takes place between what was predicted and what was observed in the previous step. In the last step (Act), action is taken on the causal system to affect the desired change.

3.13
Process Failure Modes and Effects Analysis
PFMEA
application of the FMEA method specifically to manufacturing process and activities to the product/service

3.14
prototype
early sample, model, or release of a product built to test a concept or process, but may not have been produced with the intended future processes

3.15
Quality Management System
QMS
formalized system that documents the structure, responsibilities, and procedures required to achieve effective quality management

3.16
quality plan
document, or several documents, that together specify quality standards, practices, resources, specifications, and the sequence of activities relevant to a particular product, service, project, or contract

3.17
reliability
ability of an item to perform a required function under given conditions for a given time interval

3.18
repeatability
closeness of agreement between the results of successive measurements of the same measurand, carried out under the same conditions of measurement, i.e.:

– by the same measurement procedure,
– by the same observer,
– with the same measuring instruments, used under the same conditions,
– in the same laboratory,
– at relatively short intervals of time

Note 1 to entry: The concept of "measurement procedure" is defined in VIM:2007,2.5.

3.19
reproducibility
closeness of agreement between the results of measurements of the same value of a quantity, when the individual measurements are made under different conditions of measurement:

– principle of measurement,
– method of measurement,
– observer,
– measuring instruments,
– reference standards,
– laboratory,
– under conditions of use of the instruments, different from those customarily used,
– after intervals of time relatively long compared with the duration of a single measurement

Note 1 to entry: The concepts of "principle of measurement" and "method of measurement" are respectively defined in JCGM200:2007, VIM 2.3 and 2.4.

Note 2 to entry: "reproducibility" also applies to the instance where only certain of the above conditions are taken into account, provided that these are stated.

3.20
statistical capability
statistical measure of the inherent process variability of a given characteristic in comparison to the specification limits

3.21
statistical process control
SPC
application of statistical techniques to control and monitor process. It is used to determine the stability and predictability of a process

3.22
supplier
provider of materials to an organization that builds, manufactures and/or assembles PV modules

4 Support

4.1 Resources

4.1.1 Succession planning

The organization shall plan for succession for key functions that affect customer satisfaction, quality, reliability, safety, and performance.

4.1.2 Provision of resources for product warranty system

In addition to the basic QMS-required resource planning, the organization shall determine and provide the resources needed to maintain the product warranty system, including provision of after-sales service and for identifying cause of failure and any appropriate follow-up actions such as adjustment to quality control plan or warranty recall. For repairable products, the organization shall determine and include staffing and training of service personnel to do in-field service and adequately plan for maintaining spare part depots and service centres to ensure the necessary quality of service for customers.

4.2 Monitoring and measuring resources

4.2.1 Control of monitoring and measuring equipment

Monitoring and measurement equipment referenced in the control plan shall be characterized by measurement system analysis to understand gauge capabilities (repeatability and reproducibility).

Software shall be considered an integral part of monitoring and measuring equipment and shall be appropriately controlled and validated. For changes that affect configuration, including software, the organization shall revalidate monitoring and measurement equipment.

For monitoring and measurement equipment determined to be out of tolerance at the time of calibration, corrective actions shall be taken to determine impact to the product and documented per 4.1.

4.2.2 Control of performance rating (IV) measurement equipment

For the equipment used to measure the power performance of the module, the organization shall maintain a control program compliant to IEC 60891 and IEC 60904 series of standards. Records of compliance shall be maintained.

Solar simulators shall be initially qualified according to IEC 60904-9 and shall include characterization of spectrum quality, uniformity of irradiance, and temporal instability of irradiance. Solar simulator manufacturer's data may be used to initially validate that the solar simulator meets the requirements of the organization.

Solar simulators and the methodology used for performance rating shall have an initial estimate of the uncertainty according to ISO/IEC Guide 98-3. The uncertainty analysis shall be re-evaluated at least annually. When any critical change is found in measurement uncertainty, root cause analysis shall be made prior to taking a corrective action. This information shall be recorded and maintained.

Solar simulators with a BBB rating or better are suggested for performance rating of modules, but the simulator requirement may vary with the solar cell technology, the geometry of the module, the match between the reference module and the test modules, and the power measurement uncertainty if it is indicated on the product literature.

The organization shall retain all calibration documents including the reference device calibration certificate, or a report that can be traceable to international or national measurement standards. This information shall be traceable for each module manufactured and made available to customers upon request.

4.3 Control of documented information

Records related to design, qualification, engineering changes, monitoring, and measurement of manufacturing processes and products, final testing, and customer details that are necessary to secure the warranty condition and that are defined by the organization, shall be retained for at least the warranty period.

5 Operation

5.1 Operational planning and control

In planning product realization, the organization shall also determine the following, as appropriate:

a) Product certification requirements.

b) Design lifetime aligned with the stated warranty under specific conditions and a documented method to ensure compliance to stated warranty by a combination of product reliability and after-sales services.

c) Recycling requirements at the end of the modules' lifetime.

d) Quality assurance and control measures to be applied to production to meet requirements of the applicable PV standards.

e) ESD safe environmental area.

The organization shall identify the ESD sensitive materials and components and shall determine an ESD safe environmental area and maintain an ESD safe environment at the raw material storage, processing, assembly areas, and all through packaging and shipping.

ESD requirements should consider ANSI/ESD S20.20, or equivalent standards.

If ESD protection is sufficient, and it can be determined that the electrostatic potential of the work areas is low, it would not be necessary to create a designated 'ESD safe environmental area'.

f) Packaging, storage and transportation requirements.

Customer requirements and references to related technical specifications, as applicable, shall be included in the planning of product realization as a component of the quality plan.

NOTE Since the geographies where the modules will be installed may not be identified when they are shipped, the organization is asked to pay best attention to the generic recycling requirements at the end of the modules' lifetime.

5.2 Requirements for products and services

5.2.1 Customer communication

The organization shall also determine and implement effective arrangements for communicating with customers in relation to the following:

a) Safety, workmanship warranty, output power warranty, and installation guidelines including electrical and mechanical installation instruction.

b) Application notes detailing specific attention and care needed to secure module design lifetime in the installed configuration.

c) The definition of a warrantable defect or safety critical defect and the rules or process to manage stated defects, and

d) Product recall notices.

5.2.2 Determining the requirements for products and services

The organization shall determine product warranty workmanship and power degradation and its relationship to design lifetime under specified and intended use conditions.

The organization shall incorporate requirements arising from applicable previous failure information, customer complaints, competitive analysis, supplier feedback, and other relevant inputs. The organization shall maintain traceability to these requirements.

The organization shall establish a method for specifying the nameplate power of a module with an allowed tolerance at standard test conditions per IEC 61215 series, or IEC 62108 (see 4.2.1 and 4.2.2 for proper control of solar simulators).

5.2.3 Review of the requirements for products and services

The organization shall ensure that all modified products, not covered by the retest guidelines as defined in IEC TS 62915, are qualified to all related type designs and that the modified products are evaluated for impact on the safety, performance and warranty.

5.2.4 Organization manufacturing feasibility

The organization shall investigate, conduct risk analysis, confirm and document the manufacturing feasibility at the necessary scale of the proposed products in the contract where applicable.

The organization shall manage the risks prior to manufacturing transfer.

The organization shall confirm consistency of quality of the modules between before and after manufacturing transfer. The confirmation process and the results shall be documented and recorded.

5.3 Design and development of products and services

5.3.1 Design and development planning

The organization shall include production processes in the design and development planning.

The organization shall also determine:

a) The responsibilities and authorities for a project design and development team.

b) The process to conduct DFMEAs as defined in IEC 60812 or equivalent, reliability testing, design lifetime evaluation, and product specification generation, and

c) The requirements for PFMEAs as defined in IEC 60812 or equivalent, specifications, layouts, control plan, and work instructions.

5.3.2 Design and development inputs

The inputs shall also include the following:

a) Functional, performance, and safety requirements including design lifetime, power, maintainability, durability, transportation, timing, and costs, and including the material requirements defined in IEC 61730-1.

b) Identification of product, traceability, and packaging requirements.

c) Requirements for proper handling of product and components for ESD and

d) Lessons learned from previous designs.

NOTE IEC 62759-1 defines transportation testing for designing packaging materials.

5.3.3 Design and development controls

The organization shall include standard requirements from applicable IEC and national standards for validation of the design.

Performance testing activities including durability of prototype modules shall be monitored for timely completion and conformance to requirements. Performance testing shall conform to a product and process approval procedure including a reliability test plan similar to applicable standards. As a minimum, prototyped or pre-production PV modules shall be tested according to IEC 61215 series, IEC 61730-1, IEC 61730-2, IEC TS 62915, IEC 62108, or equivalent.

Validation of the design lifetime shall be confirmed with relevant internal data or published documents and recorded. The records shall be disclosed to the auditor if requested.

Product approval should be subsequent to the verification of the manufacturing process. This product and manufacturing process approval procedure should also be applied to suppliers of key materials.

NOTE IEC 61215 series does not intend to test long term reliability of PV modules.